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The Circulation of Atmospheric Electricity: Some New Evidence

By F. J. W. WHIPPLE, M.A., F.Inst.P.

IN 1923 Mr. S. J. Mauchly, of the Carnegie Institution at Washington, published* an important paper on the diurnal variation of the potential gradient of atmospheric electricity. This paper was devoted in the first instance to the results obtained on the "Carnegie," the non-magnetic vessel which is used for oceanic surveys. Mauchly demonstrates that the regular variations in potential gradient are simultaneous over the Atlantic, Indian and Pacific Oceans. The maximum gradient occurs in the evening over the Atlantic, in the morning over the Pacific, in either case at about 20h. by Greenwich Mean Time. Similarly with the minimum which occurs at about 3h. G.M.T. The number of the observations on which these conclusions are based is small, for the averages are confined to days free from rain and other interruptions. In our diagram the diurnal variation over the oceans is shown. For comparison we have also reproduced the curves† for Dr. Simpson's observations in Lapland, at Karasjok, and in the Antarctic at Cape Evans. The Antarctic curve has been regarded as anomalous hitherto

* On the Diurnal Variation of the Potential Gradient of Atmospheric Electricity. By S. J. Mauchly. *Terrestrial Magnetism and Atmospheric Electricity*, Vol. xxviii., Sept. 1923, p. 61.

† British Antarctic Expedition, 1910-1913. Meteorology by G. C. Simpson, F.R.S., Vol. I, Discussion pp. 315 and 319.

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(Dr. Simpson suggested that it might be significant that the station at Cape Evans was between the South Pole and the South Magnetic Pole) but the substitution of Greenwich Mean Time for local time brings it into agreement with that for Karasjok and also with Mauchly's curve.

Curves which represent the diurnal variation of potential gradient at most observatories differ considerably from those before us. There are as a rule two minima, one in the early morning and one in the afternoon. It is agreed that these features depend in part on the action of dust, smoke and cloud in the atmosphere. Meteorological conditions are much simpler near the poles and over the oceans. The daily changes in wind and temperature at sea are trifling and it is very unlikely that the variations in potential gradient are due to variations in the state of the atmosphere near sea level: if we may assume that the ionization and therefore the conductivity of the air is steady then the potential gradient is a measure both of the current flowing from air to earth and of the potential difference between the earth and the atmosphere at great heights.

Accordingly Mauchly's investigations lead us to the idea that over the greater part of the globe there is a regular pulse in the flow of electricity. Near the ground the flow consists of an upward streaming of negative ions and a downward streaming of positive ions. It is this double flow which fluctuates in strength.

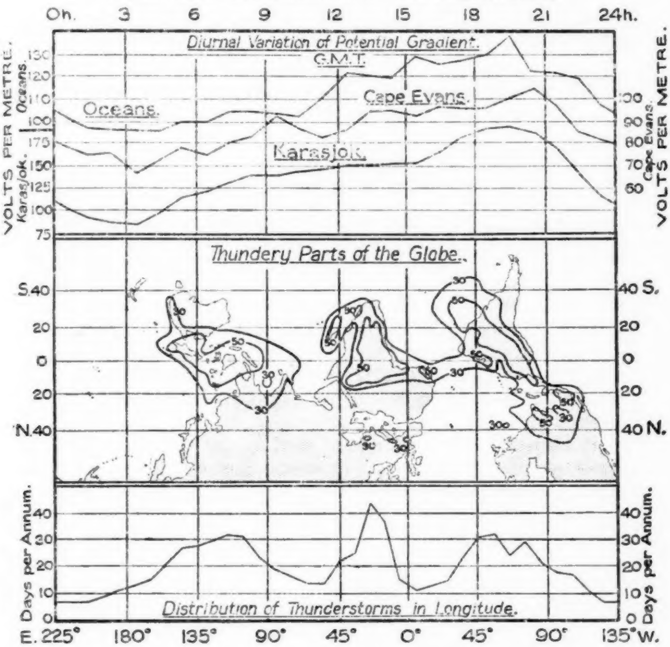
In looking for an explanation one naturally thinks of C. T. R. Wilson's suggestion* that the fine weather flow of atmospheric electricity is a bye-product of thunderstorms. There is much vagueness about the actual process, but we may accept provisionally the idea that on the balance a thunderstorm draws negative electricity from the upper atmosphere. As everyone who has dabbled in wireless telegraphy knows, there is good evidence for the upper atmosphere, say at 50 kilometres above the ground, being a comparatively good conductor; the electric current in the conducting layers consists according to Wilson's hypothesis in a flow of negative electrons from the fine areas to the thunderstorms.

The question now arises, when do thunderstorms occur. The tropical thunderstorm which comes almost with clockwork regularity day by day is always in the afternoon, and indeed in temperate regions also the afternoon is the most likely time for a storm. Let us take 3 p.m. as the representative hour for each place. The map reproduced in our diagram is drawn so as to indicate the hour by Greenwich Time corresponding with 3 p.m. local time. As the sun's motion relative to the earth is from east to west and as in drawing graphs we put late to the right

* Dictionary of Applied Physics, 1923, Vol. III., p. 104.

of early, we have here put west to the right of east and therefore drawn the map with south at the top. It will be seen that at Cape Horn 3 p.m. is 19h. 30m. G.M.T., in New Zealand 3 p.m. is 3h. 30m. G.M.T. The areas in which the annual frequency of thunderstorms exceeds 30 and those in which it exceeds 50 are shown* on the map. Below the map the average frequency

POTENTIAL GRADIENT AND THUNDERSTORMS



of thunderstorms in any longitude is shown by a graph. The average refers to places between 60° N and 50° S. Thunderstorms are comparatively frequent in the longitudes of the East Indies, Africa and south America, infrequent over the Oceans. The special point to notice is that the Pacific Ocean is much wider than the others.

Thunderstorms may be divided roughly into three classes; those which are associated with local heating of the land; those which are associated with the flow of cold air over warm water; those which are associated with the conjunction of air currents

* I have to thank Mr. C. E. P. Brooks for the statistics.

from different regions. Storms of the first class occur mainly in the afternoon hours. Those of the second class are most likely to occur in the early morning when clouds as they form are cooled by radiation. Statistics computed by Meinardus for the Indian Ocean, and by Buchan for the Challenger expedition, shew that this type of diurnal variation is characteristic of the oceans. From our present point of view the important point to notice is that the morning storms on the Pacific synchronize with the afternoon storms in Africa. The storms of the third class may occur at any time of day. The graph which represents the relation of thunderstorm frequency to longitude can not be regarded as giving directly the distribution of thunderstorms throughout the day, but it does justify the statement that thunderstorms are most numerous between 4h. and 21h. G.M.T., comparatively infrequent between 21h. and 4h. Comparison with the potential gradient curves shows that the gradient is growing during the hours of thunderstorms and that it falls off rapidly during the remaining hours.

Some additional support for the theory that the connection between these phenomena is not merely casual is to be found in the facts that the maximum of potential gradient is found both by Mauchly and by Simpson to occur later in the northern summer than in the northern winter, and that whilst thunderstorms are common in Brazil in the latter period they are more numerous in Mexico in the former, and therefore an hour later by Greenwich Time.

It is also of interest to notice that whilst potential gradient, the most commonly measured property of the atmosphere is very local and conductivity is equally local, the product of the two which represents the electric current is fairly constant over the globe. Angenheister* gives 2·2 and 1·8 microampères per square kilometre as the average current at Potsdam and Samoa respectively, the potential gradient at the two places being in the ratio 6 : 1

It is only fair to mention in conclusion that various theories other than the thunderstorm one have been put forward tentatively in explanation of the fact that in fine weather the potential gradient is positive and the earth is negatively charged. The thunderstorm theory has now the advantage of fitting in with the records of diurnal variation. The outstanding difficulty is to explain why a thunderstorm should pump electrons downwards from the upper conducting layer rather than upwards into that layer.

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*Die Luftelektrischen Beobachtungen am Samoa-Observatorium, **1906, 1907, 1908**, by G. Angenheister. ***Abhandlurgen der Königlichen Gesellschaft der Wissenschaften zu Gottingen. Mathematioch-Physikalische Klasse. Neue Folge. Band IX. Nro. 2.***

The Unprecedented Rainfall at Cannington

By J. GLASSPOOLE, M.Sc.

IN view of the unprecedented nature of the rainfall of August 18th-19th at Cannington, in Somerset, between the Quantock Hills and the River Parrett, an inspection was authorised by the Director of the Meteorological Office, and, on September 16th, I visited the area affected by the floods.

Some details have already been given in this magazine.* The most important were :—

(1) the measurement of 9 inches of precipitation in one day at Brymore House near Cannington, the second largest fall ever recorded in one day in the British Isles.

(2) the estimate that 8½ in. of this precipitation fell in 4½ hours.

(3) the division of the area of damage done by flood into two areas—(*a*) from Stogursey to Cannington, and (*b*) on the Polden Hills.

(4) the recurrence of heavy rain in this district. On June 28th, 1917, the day of the Bruton floods, the measurement at Brymore House was 4·91 in.

The rain-gauge at Brymore House, which recorded 9 in., was especially examined. The gauge and measure were accurately graduated, the exposure was excellent and the gauge could not have been flooded. Mr. Kendall is to be congratulated on having taken every possible precaution to obtain an accurate reading. The next largest rain-gauge measurement is that of 5·6 in. at Ashford House. The large value at Brymore House is also confirmed by observations from cattle tubs and troughs; both at Cannington Park and at Farm near Fiddington measurements of about 10 in. were made. The map shows the probable distribution of the rainfall for the 24 hours from 9 a.m. (G.M.T.) on the 18th, the actual readings being indicated. Mr. Kendall reads his gauge each day at 8 a.m. (G.M.T.) His readings were 9·04 in. and ·75 in. for the 18th and 19th respectively. On the 19th, steady rain fell from 6.30 to 10 a.m. (G.M.T.) It is reasonable to take the fall for the 24 hours from 9 a.m. (G.M.T.) on the 18th as 9·40 in.

Mr. Kendall adheres to the estimate, that 8½ in. fell in 4½ hours from 2 to 6-30 a.m. (G.M.T.) on the morning of August 19th. Evidence from other sources leaves little doubt but that this is substantially correct. Some reports refer to heavy rain by 1.30 a.m. (G.M.T.), and others to heavy showers earlier. Probably there were variations in different localities. A conservative estimate is that at Brymore House at least 8 in. of rain fell in the 5 hours from 1.30 to 6.30 a.m. (G.M.T.) A comparison

* Vol. 59, Sept., 1924, p. 187.

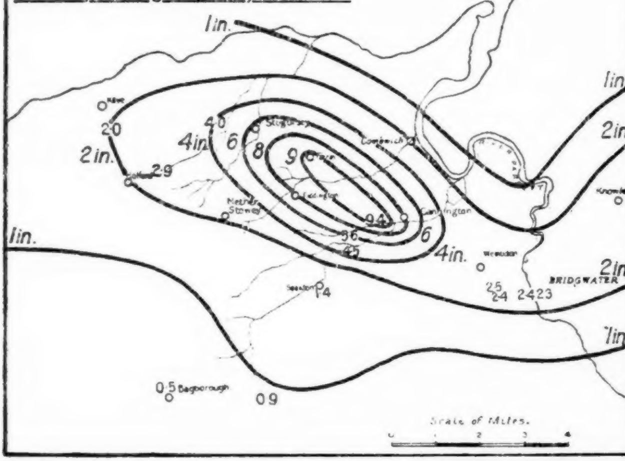
of these figures with those for other notable storms is not without interest :—

Cannington. Brymore House. Aug. 18th, 1924.	Louth. Elkington Hall. May 29th, 1920.	London. Campden Hill. June 16th, 1917.	Norwich. Ipswich Rd. Aug. 26th, 1912.
8 in.	4·59 in.	4·65 in.	4·90 in.
5 hr.	3 hr.	$2\frac{1}{2}$ hr.	6 hr.
1·6 in/hr.	1·5 in./hr.	1·9 in./hr.	0·8 in./hr.

This fall of 8 in. in 5 hours must therefore be regarded, when both the amount and the period are taken into account, as one of the most remarkable on record.

In the Polden Hill area, the contour of the land appears to have assisted the water in causing damage—the water ran rapidly

Rainfall, 18th August, 1924, in Inches.



off the hills—and at Knowle the large amount of earth which had to be removed from the road was mainly due to the steepness of the bank. The largest actual rainfall measurement is 2·9 in. In the Cannington area there was a great deal of hail ; probably one-third of the precipitation fell in this form. Much damage was done by the hail to plants and trees, especially the north-west sides, but the hail cannot have been unduly large for, so far as I am aware, no glass was broken.

During the storm, the rain flowed along the roads, which are generally below the surrounding fields. As a result, in many places the banks collapsed. The Engineer to the Bridgwater Rural District Council estimates that 2,000 tons of earth banks

[*To face page* 206.

DAMAGE DONE BY FLOODS AUGUST 19TH, 1924.

OPPOSITE BRYMORE LODGE.

AT EDBROOK FARM.

had to be removed from the roads in this area. I was particularly impressed with the damage done along the road from Fiddington through Edbrook Farm to Cannington. Similar denudation was done by the streams in their natural courses, but this is more difficult to estimate.

The map shows that the area of heavy rainfall is drained by three streams: One flowing direct to the sea, and the other two into the River Parrett. One of these drains the greater part of the Brymore Estate and flows through ponds there. These ponds filled and overflowed. The flood spread eastward, until it reached another stream of water running northward along the main road. There is a bend in the road here, as shown in the photograph, and some 30 yards of railings were blocked by straw, hedge trimmings, etc., and the water held up. Eventually the wall gave way in one solid block for 20 yards. The photograph shows the fallen wall as well as the remains of the obstruction at the foot of the railings. At this point the inhabitants of the one storey lodge of the Brymore Estate, to the right of the road in the photograph, were compelled to pull a table on the bed and remain on top of it for two hours until the water subsided. Some telegraph poles were carried over the hedge here.

At Fiddington, two interesting examples of the change of course in the stream are apparent:—

1. Formerly the stream flowed by the side of a pond, but when in flood some boulders, gravel, etc., were deposited as the stream broadened out here, and now the course is through the pond.

2. Further on, the deposit holds back the water to a greater depth and the bulk of it passes down a side stream, which previously was insignificant.

The lower photograph illustrates the damage done at Edbrook Farm. The water flowed on to the River Parrett, through Combwich, where much flooding occurred. The water ran over the top of the bridge and the stream rose no less than 6 feet within 20 minutes.

It is fortunate that this rain fell so near a large river and the sea. The damage must have been much greater if (1) the three streams had joined, (2) the country had been hilly, and (3) the streams had flowed through a town. Apparently the amount and intensity of the rainfall were greater at Cannington than in the disastrous Louth flood, when 22 people were drowned.

The first glider contests to be held in Italy opened on October 6th on the Sisemola Hills near Asiago. Unfortunately, only very light breezes (about 8 ft. per second) occurred on that day, so that few flights could be attempted.

Official Publications

The following publications have recently been issued :—

PROFESSIONAL NOTES—

No. 36. *On the Inter-Relation of Wind Direction with Cloud Amount and Visibility at Cahirciveen, Co. Kerry.* By L. H. G. Dines, M.A., A.M.I.C.E., and P. I. Mulholland, B.Sc. (M.O. 245p.)

Valencia Observatory, Cahirciveen, is maintained by the Meteorological Office as a post where the weather of the Atlantic seaboard can be studied. In this contribution to the series of *Professional Notes* the observations of cloud amount and of visibility are discussed. As was to be expected, the highest proportion of cloud occurs with winds from the Atlantic ; on the average, when there is a south wind at the Observatory, so that the drift of air at a moderate height is probably from south-west, 91 per cent. of the sky is covered with cloud. The clearest skies occur with calms in spring and with north-east winds in winter and autumn. As to visibility, we learn that dry winds from the north are most favourable, east and south-east winds the least.

The occurrence of reddish brown dust haze is systematically noted at the Observatory, and it is shown that such haze is to be attributed to smoke reaching the Irish coast from the English industrial districts, 350 miles away. Will there be a note in the *Meteorological Magazine* of 1934 recording the growing rarity of this phenomenon and attributing it to the restriction of atmospheric pollution ?

Book of Normals of Meteorological Elements for the British Isles for periods ending 1915. *Section* V. Monthly Normals for Rainfall Stations. (M.O. 236.)

The attention of readers of the *Meteorological Magazine* who are interested in rainfall observations is called to the publication by the Meteorological Office of the fifth section of the Book of Normals. In this section the average rainfall at each of 578 stations is given for each month of the year. The normals were computed in the British Rainfall Organization under the superintendence of Mr. Salter, whose death occurred when the work was practically completed.

The stations to which the statistics refer are generally such as were in continuous operation during the whole period of 35 years from 1881 to 1915, but in some cases it was found necessary to utilise observations covering a shorter period and make adjustments with the aid of the records of other stations.

There are practical advantages in the choice of the particular period 1881 to 1915 for the averages, and it is satisfactory to know that investigation has shown that these averages are in close agreement with those for very long periods to which the name "normals" is appropriate. To illustrate the way in which the stations are distributed we take as an example the County of Cumberland. There are 10 stations in the county. In the Lake District we find Seathwaite with a normal annual rainfall of 129 in., Wythburn with 88 in., and Lorton with 54 in. The coastal districts are represented by stations at Aspatria, Ravenglass and Whitehaven, each with an annual rainfall of about 42 in. Four stations in the Valley of the Eden have about 33 in. a year. The wettest month of the year is December except in the north of the county where August takes precedence. For Scaleby Hall, near Carlisle, the normals for the six wettest months are August 4·11, October 3·34, July 3·27, December 3·21, November 3·00, September 2·70. The driest month of the year is April except at Seathwaite and Wythburn where the minimum rainfall is in June.

A useful addendum to the tables for the individual stations is the table showing the average monthly rainfall for England, Wales, Scotland and Ireland. This table was computed by estimating the rainfall at numerous points uniformly distributed over the map.

The Observer's Primer, being short instructions on the method of taking and reporting readings of temperature and rainfall. (M.O. 266.)

These instructions which were prepared primarily for the use of meteorological observers in British Crown Colonies are written in simple language and will be of interest and value to those who wish to take observations for their own purposes. They are completed by a statement of the daily routine on a single sheet, which is to be cut out, pasted on a card and hung up for constant ready reference.

Errata

June, 1924, page 124, line 37, *for* "As in April numerous secondary depressions" *read* "Many anticyclones."

July, 1924, page 145, line 38, *for* "5° F." *read* "·5° F."

September, 1924, page 185, line 12 "for August 1924," *should read* "for September, 1924."

September, 1924, page 190. The first line should come at the bottom of the page.

Correspondence

To the Editor, *The Meteorological Magazine*

Precision in Rainfall Measurement

THE introduction of the new rain measure* is an immense step towards accuracy in the measurement of small amounts of rain. But there is a matter, closely connected with this refined measurement, to which, I believe, no attention has ever been given. The inside of the collecting bottle is always wet after draining it into the measure. If the bottle was dry inside when rain began to fall, a quantity of water, varying according to size of bottle from ·001 to ·003 in. of rain will be left as a film inside the bottle and lost to measurement. This quantity, by itself, is unimportant, but it may make all the difference between less or more than ·005, and therefore between recording a trace or a rain day. The remedy obviously is, always to wet the inside of the bottle which is to be placed in the gauge. I find by careful experiments that, if a small very accurately measured amount of water is put into a previously wetted bottle, I get the exact amount out when I drain the bottle into my measure. The most convenient way of working is to use two bottles; carry one, previously wetted and drained, to the gauge; substitute it for the bottle in the gauge, and carry the latter to the house, where it is so drained into the measure as to leave its interior in the same state of wetness as when it was placed in the gauge.

MORTYN J. SALTER.

Bank House, Mickleton, Campden, Gloucester. *Sept. 16th*, 1924.

[Mr. Salter's suggestion may be commended to observers though it seems doubtful whether it would secure the advantage he claims for it. As a general rule the bottle which had been wetted and drained would be dry before the next shower. On the other hand the convenience of having a spare receptacle to slip into the gauge when it happens to be raining at the observation hour is considerable.—ED. *M.M.*]

A Remarkable Thunderstorm

NOT seeing any notice of the remarkable thunderstorm which passed over West Kent on September 8th last, in your issue for September, I am venturing to send you a few notes thereon.

At 1 a.m. (G.M.T.) on September 8th, a storm of cyclonic violence burst suddenly over this district, and at this particular station (Hawkenbury, Tunbridge Wells), during the 15 minutes the storm lasted 0·58 in. of rain was deposited in the gauge.

* See the *Meteorological Magazine*, Vol. 59, Sept., 1924, p. 193.

The wind blew with great violence from the north-west, and the rain was intermixed with a great deal of hail. The lightning was practically incessant during the period named.

From reports from the surrounding districts, however, it would seem that Tunbridge Wells passed between two separate storms, as on the one side the hop-gardens in the neighbourhood of Tonbridge and Paddock Wood suffered severely from the effects of the high wind which unroofed "hoppers'" huts and did other widespread damage; whilst on the other side, at Frant and Wadhurst, horses were killed by lightning, and large oak-trees had their tops twisted completely off by the force of the wind, which was evidently of a cyclonic character. Trees were also damaged at Pembury.

Incidently I give the readings of instruments taken at 9 p.m. (G.M.T.) on the 7th, which show that the thunderstorm was of a "cyclonic" rather than of a "summer" nature. Bar. (corrected) 29·50 in., therm. 64° (during day max. temp. 68°, min. temp. 58°); wind S., force 0, cloud 10.

D. W. HORNER.

Sydenhurst, Tunbridge Wells. Sept. 30th, 1924.

The Control of Fire-Damp by Atmospheric Pressure

MARSH gas is met with in the Kimberley mines. It appears to be derived from the black shales in the country rock through which the diamond pipes penetrate. When the rock tunnel surrounding the Bultfontein Mine at the 1,000 foot level was being made it intersected, at one spot, a number of fissures which discharged the gas in quantities sufficient to be dangerous. Colonel Stokes has dealt with the situation by having a 2½ in. iron pipe cemented into one of the exposed fissures and sealing up all the others. The gas streaming out of the iron pipe is kept alight always, burning like a great torch without smoke. In case the flame should become extinguished at any time, compressed air is available with which to set up temporarily a sufficient circulation of air to clear the tunnel of most of the unburnt gas that might accumulate.

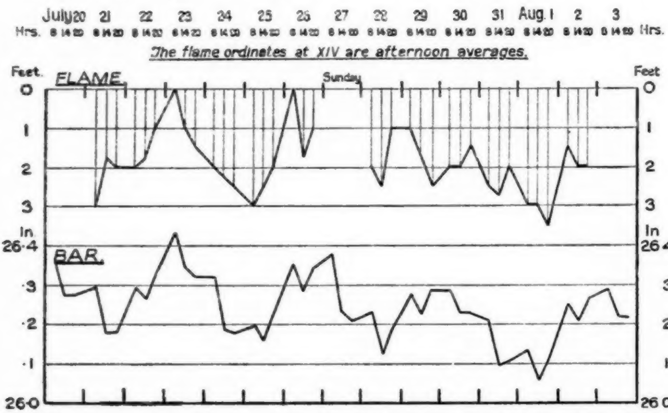
Mr. Parry's analysis of a sample of the gas gave the following result:—

	%		%
Methane ..	54·02	Oxygen	2·10
Nitrogen ..	43·36	Carbon Dioxide ..	0·52

To ensure that the gas should not be contaminated with the air of the tunnel a tube was inserted in the discharge pipe, and the gas was drawn from behind the flame through the tube.

The meteorological interest of the matter, is that the flame varies in length from time to time, from a few inches to a few feet according to the varying pressure of the air. The annexed

diagram shows how close the correspondence is between the estimated lengths of the flame and the air pressures as given by the observatory standard barometer at Kenilworth. When pressure is high the flame may die right away. This happened twice in the fortnight covered by the diagram. The longest flame observed came when the pressure was lowest of all. Moreover by taking flame-length averages a diurnal oscillation is indicated, the flame averaging longest in the afternoon and shortest in the morning, just when the air pressures are lowest and highest respectively. On the whole, a decrease of 0·10 in. of barometric pressure at the surface synchronises with an increase of one foot length of flame.



The flame is not very steady: it dances much like that of a wood fire in an open grate. But it is easy to make a fairly good estimate of its length and so of the relative gas pressure behind it. Later on we hope to replace estimates by accurate measurements. It is perhaps worth mention here that the estimates of length were made by one of the mine officials for record purposes only and not with any meteorological intention whatever. The relation shown by the diagram only came to light afterwards.

The fact that fire-damp in mines may be most dangerous when the barometer is low, or, rather, falling, is of course well known, and has been referred to in mining reports a multitude of times. But I do not remember a case in which the reported conditions have been as favourable as those at Bultfontein for getting a direct correlation between gas and pressure by simple routine observations.

J. R. SUTTON.

Kimberley, South Africa. Sept. 5th, 1924.

Bold Experiments in Physiological Optics

As there appears to be prevalent a belief that looking at the sun with the naked eye would be injurious to the optic nerve, I would say that for some years I have experimented with the sun by looking at it with the naked eye, and thus getting color impressions of that glowing orb. After gazing steadily for 30 seconds or more, and then closing the eyes, the red, orange and violet centre can be plainly seen. These colors blend and intermingle from time to time, but the violet and the green, the latter clearly being a blending of the violet and orange rays are the most persistent. On one occasion, on the 21st of June at 12 o'clock noon, I looked steadily at the sun for 15 minutes, changing from one eye to the other at intervals of about 30 seconds, and beyond making my eyes run there was no inconvenient effect. This was done while I was living in Atlanta, Ga., where the sun is fairly strong on the date given. As this took place 12 years ago, and, as at the age of 68 my sight is very good, I am sure that no one need to fear trying similar experiments. My own opinion is that what I have here described, repeated occasionally over a period of 20 years, has been beneficial rather than the reverse.

George Lowe.

84, *Garner Avenue, Buffalo, U.S.A. August 29th*, 1924.

The Indian Weather Review

From your remarks on the *India Weather Review* which appeared on p. 134 of the *Meteorological Magazine* for July, 1924, your readers may imagine that all the climatological data for Indian stations will in future be published together in annual volumes. I would point out, however, that most of the monthly figures now appear in the *Monthly Weather Report*, and that the two volumes, entitled *India Weather Review* for 1921 and 1922 respectively, were special publications intended to bridge the gap between the last *Monthly Weather Review*—that for December 1920—and the first *Monthly Weather Report*—that for January, 1923. A slip notifying these changes was issued with the last named report ; and they were also explained on page 1, paragraph 3 of the *Reviews* for 1921 and 1922.

C. W. B. Normand.

Indian Meteorological Department, Simla, Sept. 17*th*, 1924.

The American world flyers completed the circuit of the globe on September 28th, in the actual flying time of 367 hours, although nearly six months had elapsed since their departure from Seattle on April 6th.

NOTES AND QUERIES

Rain Gauges in the London Parks

METEOROLOGICAL observations are made regularly in several of the London Parks. The instruments are mounted on a stand in the form of a notice board with the rain-gauge on top. This type of exposure of a rain-gauge is unsatisfactory and the L.C.C. Parks Department, have now set up Snowdon rain-gauges with normal exposure. Readings from these gauges are entered on charts displayed in prominent positions. The parks concerned are: Battersea Park, Brockwell Park, Golder's Hill, Island Gardens, Telegraph Hill, Southwark Park and Victoria Park. It is usually difficult to obtain good open exposures in towns and this series of observations, with standard gauges, is therefore of importance.

Crop-Weather Stations

THE Ministry of Agriculture and Fisheries and the Board of Agriculture for Scotland, acting in co-operation with the Meteorological Office, has recently set on foot a scheme for the correlation of meteorological data with the growth of crops. Twenty stations in England and Wales and two in Scotland are to work under this scheme. At each of these places which consist of agricultural or horticultural colleges or experimental farms, a climatological station is being established. The normal equipment of a climatological station has been installed; special stress is laid on observations of earth temperature, thermometers at 4 in. and 8 in. being used. Anemometers are also being provided in cases where the work is horticultural in character. At a few of the stations, *e.g.* Rothamsted, meteorological work has already been carried out for many years.

In connection with the scheme a course of meteorological instruction was held at Kew Observatory on the four days, September 23rd to 26th inclusive. The instructor was Capt. E. W. Barlow. Observers attended from eighteen of the stations and three members of the staff of the Ministry of Agriculture and Fisheries were also present.

After the Thunderstorm: An unexplained Subsidence

IT is not unusual after severe thunderstorms to hear of holes in the ground which are attributed to the heavy rain. Such was the case in the storm at Cannington on the morning of August 19th.

The hole was in a field near Brymore House. It was circular,

about 6 ft. in diameter and 1 ft. to 2 ft. deep. The turf still remained on the sunken ground and the sides were clean cut and not washed. The hole resembled, as much as anything, the falling in of an old well, but no confirmation of this theory could be obtained. The geological formation may have been responsible, soft earth being washed away in the abnormal rain. The surface ground may have collapsed with the extra weight of wet soil as the water drained away. Mr. A. D. Turner, of the Somerset Farm Institute, Cannington, who kindly inspected the hole subsequently, is also of the opinion that it was not caused by any surface agent but was due to a subsidence which occurred after the heavy rain had ceased.

J.G.

The Aeroplane as an Aid to Pilot Balloon Work

THE suggestion was made some time ago that it would be advantageous on occasion to release pilot balloons from aeroplanes instead of from the ground. A balloon which starts from the ground in a strong wind is carried a great distance horizontally before it reaches a considerable height: if the observations could be commenced with the balloon nearly overhead and already 10,000 ft. up, the chance of keeping it in sight up to great altitudes would be greatly increased. The results of preliminary experiments made at the Royal Aircraft Establishment, South Farnborough, have now been reported.

Attempts to release balloons by hand from the cockpits of aeroplanes having met with little success, various devices for carrying a balloon outside a machine's fuselage were tried. Boxes and holding-down tapes proved useless in wind channel experiments: eventually a hemispheric bowl was designed, and this has been used successfully. The 18-in. diameter aluminium bowl used is supported by three tubular steel legs attached to the top of the fuselage aft of the observer's cockpit. It is offset to starboard with its opening facing aft, the plane of its rim being at an angle to the fore and aft line of the machine. This arrangement is adopted to permit the slipstream to carry the balloon to starboard of the tail.

A balloon placed in the bowl is held in position by a shaped canvas cover which is secured by a cord passing round it behind the beaded edge of the bowl's rim. This cord can be released quickly by withdrawing a pin passed through loops in the cord. The cover is permanently attached at one point to prevent its being carried away when released. A large number of small holes drilled in the bowl allow air to pass inwards from the front, which assists the balloon to escape from the bowl when the released cover has been stripped off by the slipstream. Since

the bowl sets up severe stresses in a machine, it is impossible, with the machines available, to fit a bowl large enough to carry a large balloon inflated so as to give it a lift of 500 ft. per minute, especially as the balloon expands as the height increases.

There is no difficulty in picking up the released balloon with a theodolite, provided that the aeroplane is well in the field of view. The simplest method is for the aeroplane to make a pre-arranged signal over the aerodrome and then fly straight up wind for a minute or two before releasing the balloon, thus reducing the angular velocity to a minimum and allowing time for the ground observer to sight on the aeroplane.

Ballon Sonde Ascent over the Sea

A DINES meteorograph was sent up by Commander Garbett from H.M.S. Kellett (Commander E. F. B. Haselfoot, D.S.O., R.N.), in the evening of June 16th last from a position in the English Channel. Two Pirelli balloons, each of 1·4 kg. weight, were employed in tandem. The first, with a free lift of 3·6 kg., acted as the lifter and was attached to the line through the medium of an automatic dropper set to release it from the line at a height of about 5½ km. The second balloon was permanently attached to the line and served to call attention to the instrument after the fall and prevent it being submerged; the free lift of the latter was 0·9 kg., while the total weight lifted, apart from the two balloons, amounted to some 1·8 kg. The Dines meteorograph was attached at about 5 m. below the second balloon and at a further 9 m. below that was fixed a sea anchor.

The ascent proved quite successful, the lifter balloon was set free at the predetermined height while the rest of the apparatus fell into the sea at a point 9 km. north by west of the position of release. It was picked up almost immediately by an Eastbourne boat-owner and the instrument was returned in due course. The lifter balloon was followed by means of glasses, and is thought to have burst at a height of about 12 km. The temperatures and pressures obtained from the record are as follows:—

Height above M.S.L. k.m	Pressure. mb.	Temperature. Abs.
0·0	1014	293
1·0	902	289
2·0	801	283
3·0	709	279
4·0	626	271
5·0	550	264
5·4	520	262

This is the first ballon sonde ascent to be made from the sea

by the British Meteorological Office. It is a branch of the work which could be developed with advantage to meteorological science.

20½ Kilometres Up

Two ballon sonde ascents were made from the meteorological station at the Sealand Aerodrome, near Chester (formerly known as Shotwick), at 7 a.m. on July 14th and 15th last, each of which reached a height of about 20½ kilometres. There has been much difficulty in obtaining good balloons since the war, and this is the greatest height reached in Great Britain for 12 years. The second balloon was followed by Capt. Jackson with a theodolite and seen to burst 75 minutes after the start; it is therefore possible to calculate the mean rate of ascent, 276 metres per minute. The balloon at the start was 1·4 metres in diameter. It may be noted that, if a formula of the type $V=q\ L^{\frac{1}{2}}\ (L+W)^{-\frac{1}{3}}$ be applicable,* a value of q equal to 131 is demanded for a balloon of this size as against 84 for pilot balloons.

The place of fall of the balloon sent up on July 15th was in the same azimuth as the point of bursting and gives a means of determining approximately the ratio between the mean rates of ascent and fall; it is necessary for this purpose to assume the wind to have been the same in each layer during the two periods that the balloon was traversing it, up and down. The approximate computed rate of descent of the instrument and burst balloon was 830 metres per minute, three times the rate of ascent.

L. H. G. DINES.

A Monthly Bulletin for Brazil

SENOR SAMPAIO FERRAZ, the energetic director of the Brazilian Meteorological Service is an enthusiastic advocate of the prompt circulation of weather reports. Does he not send us a monthly message for publication in the *Meteorological Magazine?* He has now responded to a resolution of the International Meteorological Conference held at Utrecht last September, and commenced the publication of a monthly bulletin. This bulletin is to be issued on the 14th of each month. In addition to the usual meteorological statistics, the bulletin includes an aerological and

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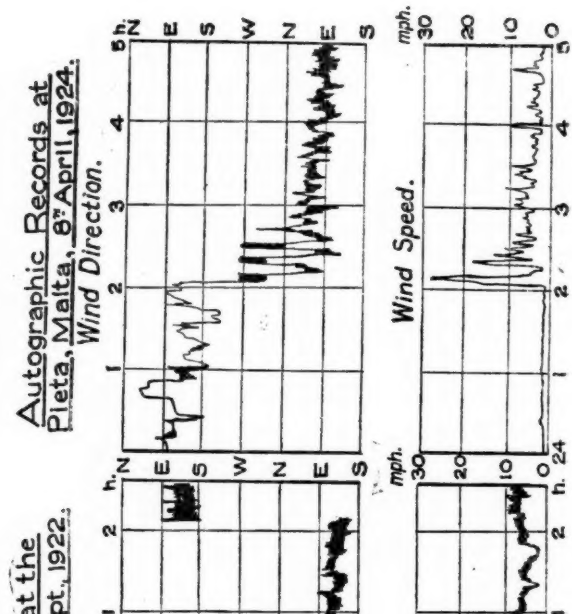
* In the formula V=upward velocity in metres per minute, L=the free lift, and W=the weight of the balloon, both in grammes. See the *Meteorological Magazine*, Vol. 55, May, 1920, p. 67.

The latest discussion of the subject of the rate of ascent of balloons is by W. C. Haines in the *Monthly Weather Review*, Vol. 51, May, 1924, p. 249.


Autographic Records at the University Valletta, 1st-2nd Sept. 1922.
Wind Direction.
Wind Speed.
mph.
Autographic Records at Pleta, Malta, 8th April, 1924.
Wind Direction.
Wind Speed.
mph.

meteoro-agricultural synopsis and a rainfall map covering the more closely populated half of Brazil. The first number gives some particulars of the rainfall at Rio de Janeiro on April 3rd and 4th, 242 mm. (9·53 inches) in 24 hours, the highest amount in such a period, at any rate since 1872.

Sudden Changes of Wind at Malta

THE anemograms reproduced on the opposite page illustrate peculiar changes of wind which occurred at Malta in September, 1922, and April, 1924. In each case there was an interruption of a light surface wind, easterly or southerly, by gusts from the west. A sudden increase of pressure (of the order of 2 mb.) accompanied the onset of the oscillations but there were no appreciable variations in temperature and relative humidity, and therefore there is no evidence of a fresh supply of air at the surface. Both disturbances occurred at night. In the case of the disturbance of September 1st-2nd, 1922, the cloud was mostly alto-cumulus and cumulus. Upper winds at Malta were north-westerly. In the example of April 7th-8th, 1924, the first gusts were westerly and afterwards alternately easterly and northerly, the latter direction changing from north-west to north-east as time went on ; but at this stage the gusts were already light and their directions probably have no significance. The first few gusts had velocities diminishing in geometrical progression as in the case of the pressure oscillations described in *Nature* by Professor Duffield.* The weather at this time at Malta was exceptional owing to the prevalence of mist and fog. Stratus and fracto-stratus often obscured the hills which rise to 400 or 600 feet. After the disturbance had passed the surface easterly wind was stronger than previously. Owing to the fog there had been no observations of the upper winds on the previous day.

The distribution of pressure was very similar in the two cases. The western and central Mediterranean was an area of low pressure and slight gradients, which were later replaced by a steep gradient for north-westerly winds. The cooler north-westerly winds reached Malta at the surface thirty-six to forty-eight hours after the occurrences just described. There were also minor disturbances which occurred by day as well as by night.

For permission to use the autographic records of the University Observatory the writer is indebted to the courtesy of Dr. T. Agius.

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* *Nature*, London. Vol. cxi., 1923, p. 598.

The Penetrating Radiations of the Upper Air

At a lecture delivered on June 19th, at University College, London, Professor R. A. Millikan, the distinguished physicist whose experimental work on the sub-atomic structure of matter has been so fruitful, gave a most interesting account of his so far unpublished work recently carried out in America to trace the origin of the so-called "penetrating radiation" which is known to be universally disseminated in nature.

The existence of this radiation, which, as Dr. Simpson has pointed out*, is of considerable interest in atmospheric electricity, was first suspected by H. L. Cooke in 1903, and more fully investigated by V. Hess, after whom the phenomenon was known as Hessian Radiation. From balloon ascents made in June, 1914, Kolhörster found that the number of free ions per cubic centimetre of air in a lead container decreased up to a height of about 1,500 metres, as would be expected in view of the fact that very considerable radio-active emanations are given off from the earth's surface, but that at greater elevations the ionisation increased with height, to the limit reached in the observations (9 kms.). This could only be explained (1) by supposing the ionisation to be due, in part at least, to very hard rays of extra-terrestrial origin, or (2) by assuming the seat of a penetrating radiation to be located in the atmosphere itself. Kolhörster, from the results of his observations, assumed the first alternative. The thickness of the atmosphere, expressed in terms of equivalent absorption by lead is about 80 cms., so that the radiation, if of cosmic origin, would have to be very penetrating, and Kolhörster computed its absorption coefficient as being about 1/10 of that for γ rays.

Prof. Millikan's observations were made during the past year at Mount Whitney, California, and Kelly Fields, Texas. From the latter place, free balloons were sent up carrying a specially designed apparatus weighing only 187 grams, which possessed a photographically recording Wulf electrometer, bimetallic thermometer, barometer (for obtaining the height) and watch for rotating two photographic films—one of which received the electrometer record and the other the barometer and thermometer traces. The results of these ascents may be summarised as follows:—

(1) A height of 17 kms. was reached (*i.e.*, twice that of the Kolhörster observations).

(2) A considerable increase of ionisation at high altitudes was observed; but

(3) The amount of increase was only about one-quarter of that to be expected from Kolhörster's work—thus showing that his conclusions need revision.

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* *Nature*, London, Vol. 99, 1917, p. 123.

During May of this year observations were continued on Mount Whitney, and the coefficient of absorption by lead of the radiation was determined as 0·4, which is almost identical with that for γ rays from Thorium D. From this and the preceding balloon experiments, Prof. Millikan concludes that the so-called penetrating radiation in the upper air, which is manifested inside the vessels used, does not penetrate from outer space, but is of local origin in the atmosphere itself.

In this case, the question as to why radio-active materials are present in larger quantities at 17,000 ft. than at the surface, has still, of course, to be answered. It may possibly be due to some radio-active gas or dust settling in the atmosphere, which may, indeed, even come from the solar protuberances; there is also no reason to suppose that there may not be in the sun itself an unknown element of higher atomic weight than Uranium (>92), which would, of course, be radio-active. Further observations on this difficult problem of meteorology are particularly desirable.

C. V. OCKENDEN.

Reviews

Hints to Meteorological Observers. By the late Wm. Marriott. Eighth edition revised by R. Corless, O.B.E., M.A. 8vo., $9\frac{3}{4} \times 6$, pp. 95, *Illus.* London: Edward Stanford Ltd., 1924. 3s.

William Marriott, the Assistant Secretary of the Royal Meteorological Society from 1872 to 1915, was a keen observer himself, and was in close touch with observers of all classes. The manual which he prepared for the Society, *Hints to Meteorological Observers*, contained just the right amount of information put in just the right way. Since the seventh edition, published in 1911, was exhausted there has been no book which could be regarded as taking its place, for the *Observer's Handbook* of the Meteorological Office is a much heavier work. The Meteorological Society has done well to issue a new edition of the Hints. This edition has been prepared by Mr. R. Corless, one of the Honorary Secretaries of the Society. As Superintendent of the Climatology Division of the Meteorological Office, Mr. Corless can write with authority on the present practice in observing.

The additions which catch the eye are the instructions for estimating visibility and turbulence. In the latter case observations are recommended to the observer who happens to be stationed not far from a tall chimney. By prolonged eye observations or prolonged photography, the shape of the space containing the smoke is obtained, and from measurements of this space and of the time taken by smoke to pass along it, the

" diffusivity " is computed. Perhaps with some experience an observer will be able to simplify the routine and merely mark on a fixed vertical scale the apparent range of the points where the trail cuts the scale. Systematic observations of this sort would be of great interest. As Mr. L. F. Richardson, to whom the instructions are due, points out, the value of the " diffusivity " may vary from ten to a million in centimetre-second units. As to visibility the observer is recommended to work with a series of objects at specified distances and to enter in the register the letter corresponding with the most distant selected object which is visible. A new convention, which turns the difficulty met with where a complete series of objects is not available, is that whilst capitals are used to denote the visibility of actual objects small letters may be used for estimates of intermediate degrees of visibility.

We learn from the preface that " In deference to the practice of the Meteorological Office, instructions for observing barometers graduated in millibars, and for reducing the readings, are included ; as also aie instructions for measuring the rainfall in millimetres. The old ' mercury-inch ' pressure unit and the ' inch ' rainfall unit have, however, been retained, as many instruments are still in use which employ those units." It should be mentioned that the same scheme is adopted for the reducing of millibar readings and inch readings of the barometer so that the tables for the two units correspond.

Another change is to be found in the tables provided for the determination of humidity from readings of the dry and wet bulb thermometers. Previously Glaisher's system had been used. Now we find tables based on what are generally known as the moderate wind formulæ, an indication that British meteorologists are coming into line with the general practice abroad wherever humidity is estimated from readings of thermometers in the Stevenson Screen.

The new edition of the Hints will be a useful work of reference for every observer.

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*Anleitung zur Anstellung und Berechnung der Beobachtungen an den Deutschen Meteorologischen Stationen. Ertser Teil.** Edited by G. Lüdeling. Size 11×8, pp. vi.+76+(6). *Illus.* Berlin : Behrend & Co. 1924.

This is the third edition of the first part of the former Prussian *Observer's Handbook.* At the suggestion of Dr. Schmauss, Director of the Bavarian Service, the book has been written to meet the requirements of observers at second and third order stations in the whole of Germany, with the result that a common

* Instructions for arranging and computing observations at the German meteorological stations, Part I.

form of monthly return has now been adopted for the whole of the country. Dr. Lüdeling is responsible for the new edition.

Certain portions of the second part of the Prussian *Anleitung*, notably sections on an aspirator for the wet bulb, the determination of depth of snow, the Campbell-Stokes sunshine recorder and phenological observations have been included in this edition, while a brief section on visibility has been added. It is noticed that the German scale of visibility differs somewhat from that adopted by the International Meteorological Committee.

It is not proposed to issue in the near future a new edition of the second part of the Prussian *Anleitung*, dealing with instruments and observations which do not usually form part of the equipment and programme of a second order station, because many copies of the current edition still remain.

News in Brief

Mr. A. E. Mayers, a clerk in the Shoeburyness Meteorological Office, has been awarded a silver medal in the recent examination in Machine Construction and Design by the National Union of Teachers.

According to the *Times*, M. Jules de Payer is to head a French expedition which will attempt to fly across the north polar regions from Franz Josef Archipelago. M. de Payer expects to leave for the Arctic next month.

The Weather of September, 1924

UNSETTLED weather, with heavy rain at times, prevailed throughout the greater part of the month, although there were fine periods in some districts. From the 2nd to the 6th, fine, sunny conditions were experienced in the northern part of the British Isles, as the anticyclone centred near southern Norway extended also across Scotland ; as much as 13 hours bright sunshine were registered at Crathes (Kincardine) on the 4th, 12·9 hours at Lerwick on the 5th. In the south, the weather was cloudy and rain fell on most days, 31 mm. (1·22 in.) occurred at Norwich on the 4th, but elsewhere the amounts were moderate or slight. On the 6th the conditions changed, a depression approached from the Atlantic and crossed the British Isles from south-west to north-east. This caused general heavy rain on the 6th, 7th and 8th. The heaviest falls occurred on the 7th, when 61 mm. (2·41 in.) fell at Ballynahinch (Galway) ; 57 mm. (2·26 in.) at Aasleagh (Mayo), and 54 mm. (2·13 in.) at Inverness. Thunderstorms occurred in many parts of England between the 7th and the 9th. From the 10th to the 19th depressions were generally centred to the north-west of the British Isles, and south-westerly winds, strong at times, prevailed with frequent heavy rain, but

some bright days *e.g.* the 14th and 18th, when about 11 hours bright sunshine were recorded at several places in England and Scotland. On the 16th, the rainfall was particularly heavy in North Wales and the Lake District, 91 mm. (3·58 in.) being measured at Carnarvon and 75 mm. (2·95 in.) at Dungeon Ghyll. There were also heavy falls in Kerry on the 19th, *e.g.* 63 mm. (2·48 in.) in the Slaheny Valley. After the 19th the depressions developed further south, and high winds or gales occurred at times on parts of our coasts, notably on the night of the 20th to 21st, when a wind of 65 m.p.h. was recorded for two hours at Southport. From the 19th to the 25th bright sunshine and heavy rain continued to alternate. The heaviest falls in this period, which were associated with a depression moving eastwards across the English Channel, occurred in Hampshire on the 25th, when 88 mm. (3·46 in.) were registered at Beaulieu, over 80 mm. (3·15 in.) at Westmeon, Petersfield, and 63 mm. (2·48 in.) at Titchfield. In the rear of this disturbance an anticyclone moved across England, giving fair weather for a day or two, though a fresh depression centred near Iceland caused heavy rain in Ireland and Scotland on the evening of the 28th, and a subsequent renewal of wet weather in England. Day temperatures throughout the month were moderate, 73° F. being the highest reading recorded, but in the earlier parts of the month the nights were warm. The total rainfall for the month was more than double the average in many parts of England and Ireland, and nearly three times the average at Birr Castle and Waterford (see p. 227). Mr. Shaw, the observer at Salcombe, Devon, writes to say that the total rainfall for the 9 months, January to September, 1924, is 817 mm. (32·16 in.), 273 mm. (10·73 in.) above the average.

Pressure being on the average below normal over the whole of western Europe and the eastern North Atlantic except between the Azores and Spain (the deficit exceeded ·5 mb. over most of the area, including the British Isles, and reached 10 mb. at Stornoway), the weather in the north-west and west of Europe was generally unsettled, with mainly south-westerly winds, much rain and many gales, while the mean temperature was a few degrees above normal. In Switzerland the temperature was normal and the rainfall local, heavy rains having caused a landslide, which swept away Someo, a village in the Canton of Ticino, while at Zurich the fall was less than usual. In France and parts of Switzerland the continued wet weather was responsible for the ruin of the wheat crop, and a very poor yield of flour is anticipated. In the Mediterranean the weather was more favourable, and very warm weather prevailed during the first fortnight, Malta reaching a maximum of 102° F. on the 10th. (The previous September record, 1853 to 1923, was 100° F.)

Among the phenomena of the month we note a heavy storm which swept over Denmark on the 11th, damaging the fruit crops and driving several ships ashore, and serious floods in Leningrad on the 23rd.*

The rainfall in India for the week ending the 24th, was reported to be scanty in the Bay Islands, Lower Burma, Central India (East), and North-west India. It was excessive in the Peninsula where the monsoon was still strong. During the last week of the month heavy rain fell in the Punjab between Delhi and Kumaon. At Mussooree 15 in. of rain were recorded in two days, and at Naim Tal 18 in. in 3 days. In the surburbs of Delhi and in parts of the Punjab over 40 villages were submerged, and many more flooded. The Ramganga, a tributary of the Ganges, rose to an unprecedented height and serious breaches have been made in the railways.

On September 7th great damage was caused by a typhoon in the port of Taihoku, Formosa. The casualties numbered over 300, 60 craft in the port were sunk, and over 100 bridges destroyed

At the end of the month there were extensive floods in the Eastern United States, and a storm on the 30th caused much damage. Many rivers were in flood, and Oneida Creek, New York, which usually has a width of 50 ft., was half a mile wide. There was a gale in New York City and an inch of rain fell. The weather was so bad that the liner Olympic had great difficulty in entering the harbour. Floods are also reported from Quebec, where the municipality of Baie St. Paul is threatened unless the water soon subsides. A fishing schooner was wrecked in a hurricane on the 4th off Newfoundland on the St. Pierre Archipelago and 24 lives were lost.

The Oxford University Arctic Expedition, recently returned to England after exploring Spitsbergen, reports that this season has been the worst for 15 years, owing to northerly gales, blizzards and sea ice.

The special message from Brazil, states that the rainfall was generally scanty, being 40 mm., 27 mm. and 59 mm. below normal in the northern, central and southern districts respectively. The crops in the southern and central districts have been badly affected by the scarcity of rain during the critical periods. The general circulation was less active than in the previous month. At Rio de Janeiro pressure was 2·5 mb. above normal and temperature ·5° F. below normal.

Rainfall September, 1924: General Distribution

England and Wales	174	per cent of the average 1881-1915.
Scotland	173	
Ireland	217	
British Isles	183	

* The newspaper reports refer to a "tidal wave." There were strong west winds up the Gulf of Finland; we have no information as to whether the Neva was in flood above Leningrad.

Rainfall: September, 1924: England and Wales.

CO.	STATION.	In.	mm.	Per-cent. of Av.	CO.	STATION.	In.	mm.	Per-cent. of Av.
Lond.	Camden Square	2·59	66	142	*War.*	Birminghm, Edgbaston	3·53	90	197
Sur.	Reigate, Hartswood	3·39	86	174	*Leics*	Leicester Town Hall	2·41	61	...
Kent.	Tenterden, View Tower	1·83	47	86	,,	Belvoir Castle	2·73	69	146
,,	Folkestone, Boro. San.	2·67	68	...	*Rut.*	Ridlington	2·64	67	...
,,	Broadstairs	1·59	40	...	*Linc.*	Boston, Skirbeck	2·12	54	120
,,	Sevenoaks, Speldhurst.	3·72	95	...	,,	Lincoln, Sessions House	2·11	54	137
Sus.	Patching Farm	3·57	91	149	,,	Skegness, Estate Office.	2·18	55	120
,,	Eastbourne, Wilm. Sq.	2·44	62	98	,,	Louth, Westgate	3·03	77	150
,,	Tottingworth Park	3·61	92	147	,,	Brigg	2·36	60	140
Hants	Totland Bay, Aston	4·65	118	209	*Notts.*	Worksop, Hodsock	2·62	67	172
,,	Fordingbridge, Oaklnds	4·53	115	211	*Derby*	Mickleover, Clyde Ho.	3·09	79	173
,,	Portsmouth, Vic. Park.	5·73	145	264	,,	Buxton, Devon. Hos.	5·29	134	163
,,	Ovington Rectory	6·05	154	264	*Ches.*	Runcorn, Weston Pt.	3·96	101	148
,,	Grayshott	5·85	148	242	,,	Nantwich, Dorfold Hall	3·51	89	...
Berks	Wellington College	3·40	86	185	*Lancs*	Bolton, Queen's Park	4·67	119	...
,,	Newbury, Greenham	4·63	118	229	,,	Stonyhurst College	4·99	127	131
Herts.	Bennington House	...	...	...	,,	Southport, Hesketh	4·72	120	172
Bucks	High Wycombe	3·76	95	199	,,	Lancaster, Strathspey	5·18	132	...
Oxf.	Oxford, Mag. College	4·06	103	242	*Yorks*	Sedbergh, Akay	7·19	183	171
Nor.	Pitsford, Sedgebrook	3·19	81	177	,,	Wath-upon-Dearne	2·65	67	168
,,	Eye, Northolm	1·94	49	...	,,	Bradford, Lister Pk.	3·46	88	167
Beds.	Woburn, Crawley Mill	3·17	80	166	,,	Oughtershaw Hall	8·39	213	...
Cam.	Cambridge, Bot. Gdns.	2·08	53	129	,,	Wetherby, Ribston H.	3·44	87	191
Essex	Chelmsford, CountyLab	2·39	61	...	,,	Hull, Pearson Park	2·27	58	132
,,	Lexden, Hill House	1·66	42	...	,,	Holme-on-Spalding	2·34	59	...
Suff.	Hawkedon Rectory	3·19	81	165	,,	Lowthorpe, The Elms	2·48	63	143
,,	Haughley House	2·42	61	...	,,	West Witton, Ivy Ho.	3·18	81	...
Norf.	Beccles, Geldeston	3·39	86	176	,,	Pickering, Hungate	2·20	56	...
,,	Norwich, Eaton	...	...	...	,,	Middlesbrough	1·83	47	110
,,	Blakeney	2·42	61	130	,,	Baldersdale, Hury Res.	3·91	99	143
,,	Swaffham	2·62	67	123	*Durh.*	Ushaw College	3·46	88	172
Wilts.	Devizes, Highclere	3·56	90	175	*Nor.*	Newcastle, Town Moor.	2·73	69	134
Dor.	Evershot, Melbury Ho.	5·19	132	195	,,	Bellingham Manor	3·30	84	...
,,	Weymouth, Westham	3·23	82	154	,,	Lilburn Tower Gdns.	3·14	80	...
,,	Shaftesbury, Abbey Ho.	3·10	79	128	*Cumb*	Penrith, Newton Rigg	...	...	...
Devon	Plymouth, The Hoe	3·88	99	158	,,	Carlisle, Scaleby Hall	3·42	87	127
,,	Polapit Tamar	4·09	104	146	,,	Seathwaite	16·25	413	164
,,	Ashburton, Druid Ho.	7·09	180	228	*Glam.*	Cardiff, Ely P. Stn.	6·74	171	217
,,	Cullompton	5·61	142	249	,,	Treherbert, Tynywaun	13·79	350	...
,,	Sidmouth, Sidmount	5·55	141	241	*Carm*	Carmarthen Friary	7·97	202	230
,,	Filleigh, Castle Hill	6·47	164	...	,,	Llanwrda, Dolaucothy	8·99	228	221
,,	Hartland Abbey	4·36	111	...	*Pemb*	Haverfordwest, Portf'd	5·35	136	...
Corn.	Redruth, Trewirgie	4·44	113	142	*Card.*	Gogerddan	7·24	184	199
,,	Penzance, Morrab Gdn.	3·57	100	122	,,	Cardigan, County Sch.	5·41	137	...
,,	St. Austell, Trevarna	4·16	106	130	*Brec.*	Crickhowell, Talymaes	8·00	203	...
Soms	Chewton Mendip	4·36	111	142	*Rad.*	Birm. W.W. Tyrmynydd	8·32	211	216
,,	Street, Hind Hayes	3·49	89	...	*Mont.*	Lake Vyrnwy	...	...	...
Glos.	Clifton College	3·82	97	162	*Denb.*	Llangynhafal	5·13	130	...
,,	Cirencester	4·29	109	190	*Mer.*	Dolgelly, Bryntirion	8·37	213	197
Here.	Ross, County Obsy.	5·08	129	251	*Carn.*	Llandudno	3·52	89	154
,,	Ledbury, Underdown.	5·10	129	267	,,	Snowdon, L. Llydaw 9	20·15	512	...
Salop	Church Stretton	4·32	110	213	*Ang.*	Holyhead, Salt Island.	6·21	157	232
,,	Shifnal, Hatton Grange	3·15	80	163	,,	Lligwy	5·94	151	...
Staff.	Tean, The Heath Ho.	3·51	89	147	*Isle of Man*				
Worc.	Ombersley, Holt Lock.	...	...	...		Douglas, Boro' Cem.	6·53	166	198
,,	Blockley, Upton Wold.	4·98	127	237	*Guernsey*				
War.	Farnborough	4·42	112	208		St. Peter Port Grange.	4·90	124	188

Rainfall: September, 1924: Scotland and Ireland

CO.	STATION	In.	mm.	Per-cent. of Av.	CO.	STATION.	In.	mm.	Per-cent. of Av.
Wigt.	Stoneykirk, Ardwell Ho	5·86	149	210	*Suth.*	Loch More, Achfary...	8·58	218	149
,,	Pt. William, Monreith.	6·07	154	...	*Caith*	Wick	4·07	103	163
Kirk.	Carsphairn, Shiel.	10·68	271	...	*Ork.*	Pomona, Deerness	5·03	128	173
,,	Dumfries, Cargen.....	5·80	147	197	*Shet.*	Lerwick	4·08	103	136
Dum	Drumlanrig	5·58	142	189					
Roxb	Branxholme	4·29	109	192	*Cork.*	Caheragh Rectory	8·62	219	...
Selk.	Ettrick Manse........	5·69	144	...	,,	Dunmanway Rectory.	8·08	205	197
Berk.	Marchmont House	3·73	95	155	,,	Ballinacurra	5·45	138	216
Hadd	North Berwick Res....	4·07	103	195	,,	Glanmire, Lota Lo. ...	6·56	167	234
Midl	Edinburgh, Roy. Obs..	2·81	71	154	*Kerry*	Valencia Obsy.	...	...	...
Lan.	Biggar	3·87	98	170	,,	Gearahameen	10·30	262	...
Ayr.	Kilmarnock, Agric. C..	5·33	135	174	,,	Killarney Asylum.....	7·32	186	204
,,	Girvan, Pinmore......	6·88	175	180	,,	Darrynane Abbey	8·67	220	244
Renf.	Glasgow, Queen's Pk..	4·51	115	163	*Wat.*	Waterford, Brook Lo..	8·12	206	293
,,	Greenock, Prospect H..	7·41	188	156	*Tip.*	Nenagh, Cas. Lough...	7·55	192	269
Bute.	Rothesay, Ardencraig.	5·66	144	140	,,	Tipperary	5·26	134	...
,,	Dougarie Lodge	6·55	166	...	,,	Cashel, Ballinamona ..	5·41	137	221
Arg.	Glen Etive...........	12·91	328	...	*Lim.*	Foynes, Coolnanes	5·31	135	190
,,	Oban	7·44	189	...	,,	Castleconnell Rec.	7·03	179	...
,,	Poltalloch	5·97	152	131	*Clare*	Inagh, Mount Callan ..	8·27	210	...
,,	Inveraray Castle......	9·27	235	144	,,	Broadford, Hurdlest'n.	8·36	212	...
,,	Islay, Eallabus.......	6·56	167	157	*Wexf*	Newtownbarry	7·34	186	...
,,	Mull, Benmore	9·60	244	...	,,	Gorey, Courtown Ho...	6·08	154	246
Kinr.	Loch Leven Sluice	4·08	104	159	*Kilk.*	Kilkenny Castle	5·75	146	249
Perth	Loch Dhu	9·05	230	158	*Wic.*	Rathnew, Clonmannon	5·63	143	...
,,	Balquhidder, Stronvar.	...	...	...	*Carl.*	Hacketstown Rectory .	6·39	162	228
,,	Crieff, Strathearn Hyd.	4·9[illegible]	125	171	*QCo.*	Blandsfort House.....	5·71	145	210
,,	Blair Castle Gardens ..	4·72	120	...	,,	Mountmellick	7·37	187	...
,,	Coupar Angus School..	3·24	80	163	*KCo.*	Birr Castle...........	6·76	171	295
Forf.	Dundee, E. Necropolis.	4·53	115	218	*Dubl.*	Dublin, FitzWm. Sq...	4·94	125	257
,,	Pearsie House	5·27	134	...	,,	Balbriggan, Ardgillan .	5·88	149	288
,,	Montrose, Sunnyside..	4·48	114	225	*Me'th*	Drogheda, Mornington	5·48	139	...
Aber.	Braemar Bank	4·75	121	189	*W.M*	Mullingar, Belvedere .	6·01	153	225
,,	Logie Coldstone Sch. ..	4·04	103	173	*Long*	Castle Forbes Gdns....	4·97	126	173
,,	Aberdeen, Cranford Ho	4·96	126	212	*Gal.*	Galway, Waterdale ...	...	...	...
,,	Fyvie Castle	4·65	118	...	,,	Ballynahinch Castle ..	9·19	233	...
Mor.	Gordon Castle........	4·58	116	183	*Mayo*	Mallaranny..........	6·85	174	...
,,	Grantown-on-Spey....	3·99	101	161	,,	Westport House......	5·01	127	141
Na.	Nairn, Delnies........	3·89	99	177	,,	Delphi Lodge	13·15	334	...
Inv..	Ben Alder Lodge	9·38	238	...	*Sligo*	Markree Obsy.	6·10	155	180
,,	Kingussie, The Birches	4·09	104	...	*Ferm*	Enniskillen, Portora ..	5·27	134	...
,,	Fort Augustus	...	...	...	*Arm.*	Armagh Obsy.	5·25	133	213
,,	Loch Quoich, Loan....	16·40	417	...	*Down*	Warrenpoint	5·61	143	...
,,	Glenquoich	14·39	365	166	,,	Seaforde	7·63	194	277
,,	Inverness, Culduthel R.	4·75	121	...	,,	Donaghadee	...	...	...
,,	Arisaig, Faire-na-Squir	7·58	193	...	,,	Banbridge, Milltown .	5·37	136	137
,,	Fort William.........	8·98	228	143	*Antr.*	Belfast, Cavehill Rd. ..	5·99	152	...
,,	Skye, Dunvegan......	6·60	168	...	,,	Glenarm Castle.......	6·59	167	...
,,	Barra, Castlebay	2·10	53	...	,,	Ballymena, Harryville	5·64	143	181
R&C	Alness, Ardross Cas. ..	6·20	157	212	*Lon.*	Londonderry, Creggan	6·03	153	183
,,	Ullapool.............	5·48	139	...	*Tyr.*	Donaghmore	6·27	159	...
,,	Torridon, Bendamph..	11·35	288	163	,,	Omagh, Edenfel	5·48	139	180
,,	L. Carron, Plockton...	5·64	143	...	*Don.*	Malin Head	5·14	130	196
,,	Stornoway	5·25	133	133	,,	Rathmullen..........	5·12	130	...
Suth.	Lairg	4·44	113	...	,,	Dunfanaghy	6·43	163	186
,,	Tongue Manse........	6·32	161	200	,,	Narin, Kiltoorish	5·97	152	...
,,	Melvich School.......	5·80	147	207	,,	Killybegs, Rockmount.	8·24	209	179

Climatological Table for the British Empire, April, 1924

STATIONS	PRESSURE		TEMPERATURE							Rela-tive Humi-dity	Mean Cloud Am'nt	PRECIPITATION			BRIGHT SUNSHINE	
			Absolute		Mean Values				Mean							
	Mean of Day M.S.L.	Diff. from Normal	Max.	Min.	Max.	Min.	½ max. and min.	Diff. from Normal	Wet Bulb			Am'nt	Diff. from Normal	Days	Hours per day	Per-cent-age of possi-ble.
	mb.	mb.	° F.	° F.	° F.	° F.	° F.	° F.	° F.	%	0—10	mm.	mm.			
London, Kew Obsy.	1012·4	− 2·0	71	29	54·0	39·6	46·8	− 0·5	44·3	77	6·9	86	+ 49	15	4·1	30
Gibraltar	1016·3	− 0·2	78	47	67·8	54·5	61·1	+ 0·1	55·4	72	4·7	79	+ 11	7	...	...
Malta	1014·8	+ 2·3	79	49	66·4	55·9	61·1	+ 1·4	56·0	78	4·2	53	+ 33	3	9·5	73
Sierra Leone	1010·4	− 0·6	93	71	90·3	75·8	83·1	+ 0·3	77·5	73	5·1	69	− 34	8	...	...
Lagos, Nigeria	1007·9	− 1·9	92	72	89·7	78·3	84·0	+ 1·7	80·3	77	5·0	192	+ 43	12	...	...
Kaduna, Nigeria	1011·0	+ 0·3	99	...	93·7	...	...	...	72·5	61	0·9	41	− 27	6	...	...
Zomba, Nyasaland	1013·6	+ 1·7	82	54	76·3	58·8	67·5	− 1·8	...	89	6·1	14	− 91	6	...	...
Salisbury, Rhodesia	1013·7	− 0·7	85	44	77·3	50·4	63·9	− 2·0	56·0	56	1·6	0	− 26	0	...	...
Cape Town	1017·2	+ 0·9	94	47	74·8	55·8	65·3	+ 2·2	59·1	62	3·4	22	− 29	3	...	...
Johannesburg	1018·2	+ 1·6	75	41	69·5	49·6	59·5	− 0·1	51·1	64	1·6	27	− 25	6	8·4	74
Mauritius	1011·8	− 2·2	85	61	81·3	70·5	75·9	+ 0·1	71·2	79	5·5	79	− 35	12	7·0	61
Bloemfontein	...	...	80	39	73·0	46·0	59·5	− 1·3	52·3	69	1·4	26	− 28	5	...	...
Calcutta, Alipore Obsy.	1005·4	− 0·9	105	73	99·4	78·6	89·0	+ 3·3	78·2	76	3·5	8	− 36	1*	...	...
Bombay	1007·6	− 1·0	94	76	91·3	79·3	85·3	+ 2·2	76·4	70	2·4	0	− 2	0*	...	...
Madras	1007·3	− 1·1	99	75	94·5	79·1	86·8	+ 1·5	79·0	68	3·8	0	− 15	0*	...	...
Colombo, Ceylon	1008·3	− 0·8	92	71	88·9	76·3	82·6	− 0·1	79·4	70	6·2	227	− 25	20	8·5	69
Hong Kong	1011·5	− 1·1	85	57	74·4	65·8	70·1	− 0·8	66·3	85	8·5	158	+ 18	13	3·4	27
Sandakan	...	...	91	75	88·4	77·0	82·7	+ 0·5	77·4	78	...	102	− 4	6	...	...
Sydney	1016·0	− 2·4	82	49	71·3	56·4	63·9	− 0·7	58·1	68	4·6	180	+ 42	15	6·2	55
Melbourne	1019·2	− 0·2	81	43	63·4	49·9	56·7	− 2·8	53·1	72	6·7	93	+ 36	13	4·1	37
Adelaide	1022·0	+ 2·2	84	45	68·2	50·8	59·5	− 4·3	53·6	64	5·9	37	− 9	14	4·8	43
Perth, W. Australia	1019·6	+ 1·2	91	48	80·5	59·3	69·9	+ 3·5	59·8	52	4·7	8	− 33	2	6·5	58
Coolgardie	1022·9	+ 4·4	94	45	77·5	52·8	65·1	0·0	56·1	42	3·7	11	− 13	1	...	...
Brisbane	1015·7	− 1·7	88	50	78·4	60·7	69·5	− 0·9	64·2	64	4·6	68	− 23	4	6·9	61
Hobart, Tasmania	1013·1	− 1·4	71	39	54·1	47·7	50·9	− 4·2	50·2	70	6·1	63	+ 15	17	5·5	50
Wellington, N.Z.	1018·1	+ 0·3	78	43	68·4	56·3	62·3	+ 5·5	57·9	75	6·9	69	− 30	8	4·3	39
Suva, Fiji	1010·8	+ 0·2	89	64	85·1	72·1	78·6	− 0·1	75·2	81	6·1	277	− 10	19	...	...
Kingston, Jamaica	1013·7	− 0·4	92	67	89·4	69·9	79·7	+ 1·3	72·5	63	3·2	21	− 10	2	...	...
Grenada, W.I.	1013·3	+ 0·7	87	71	85·4	74·0	79·7	+ 0·9	73·9	70	3·8	10	− 50	7	...	...
Toronto	1014·7	− 0·8	66	19	51·0	34·6	42·8	+ 1·4	37·8	72	5·1	65	+ 4	11	6·8	51
Winnipeg	1012·6	− 4·4	65	8	43·6	28·1	35·9	− 1·9	34·5	92	6·9	89	+ 51	16	4·0	29
St. John, N.B.	1013·6	0·0	56	23	43·3	30·2	36·7	− 2·3	33·7	82	7·0	82	− 7	13	3·4	25
Victoria, B.C.	1020·8	+ 3·5	70	34	53·8	41·2	47·5	− 0·2	42·4	75	6·0	46	+ 2	10	6·6	48

* For Indian stations a rain day is a day on which 0·1 in. (2·5 mm.) or more rain has fallen.

Victoria, B.C.	1020·8	+ 3·5	70	34	53·8	41·2	47·5	− 0·2	42·4	75	6·0	46	+ 2	10	6·6	48

* For Indian stations a rain day is a day on which 0·1 in. (2·5 mm.) or more rain has fallen.